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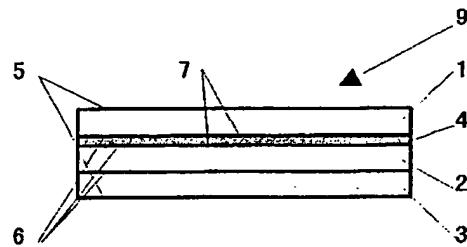
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(54) 【発明の名称】 光学フィルタとこれを用いた撮像装置およびこれを用いた撮像機器

(57) 【要約】

【課題】 画像撮像装置の小型・薄板化を目的に、光学フィルタを含めた光学系の小型・薄板化を行うための撮像素子とその方法を提供する。

【解決手段】 ニオブ酸リチウム単結晶からなる複屈折板に赤外線遮断層を積層したものを光学フィルタとし、これを撮像素子が収納されたパッケージのカバーガラスとして用いる。



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【特許請求の範囲】

【請求項1】ニオブ酸リチウム単結晶からなる複屈折板に、可視光域である波長400～550nmの光の透過率が85%以上で、赤外光域である波長725～1000nmの光の透過率が15%以下の赤外線遮断層を積層したことを特徴とする光学フィルタ。

【請求項2】上記複屈折板を複数枚積層させ、その最外面または間に上記赤外線遮断層を積層したことを特徴とする光学フィルタ。

【請求項3】少なくとも3枚の複屈折板を積層させて、各板の光軸投影方向が45度乃至90度になるようにして、透過光を正方もしくは長方分離させることを特徴とする請求項2記載の光学フィルタ。

【請求項4】上記複数枚積層させた複屈折板の少なくとも1枚を水晶に置き換えたことを特徴とする請求項2または3記載の光学フィルタ。

【請求項5】上記複数枚積層させた複屈折板の少なくとも1枚を1/4波長板に置き換えたことを特徴とする請求項2乃至4のいずれかに記載の光学フィルタ。

【請求項6】前記赤外線遮断層が、可視光域である波長400～550nmの光の透過率のP-V (Peak and Valley) 値が10%以下であることを特徴とする請求項1乃至5のいずれかに記載の光学フィルタ。

【請求項7】前記赤外線遮断層が、光の入射角度20度以内における透過率の半値波長の変動が±15nm以下であることを特徴とする請求項1乃至6のいずれかに記載の光学フィルタ。

【請求項8】可視光域である波長400nm～550nmの光の透過率が85%以上であることを特徴とする請求項1乃至7のいずれかに記載の光学フィルタ。

【請求項9】パッケージ内に収納された撮像素子の受光面の対面に、ニオブ酸リチウム単結晶からなる複屈折板を備えたことを特徴とする撮像装置。

【請求項10】前記複屈折板を複数枚積層させたことを特徴とする請求項9記載の撮像装置。

【請求項11】パッケージ内に収納された撮像素子の受光面の対面に請求項1乃至8のいずれかに記載の光学フィルタを備えたことを特徴とする撮像装置。

【請求項12】紫外線硬化接着剤または $8 \times 10^{-5} \sim 3 \times 10^{-6}$ /°Cの熱膨張係数を有する接着剤を用いて、前記複屈折板または光学フィルタをパッケージに接合することを特徴とする請求項9乃至11のいずれかに記載の撮像装置。

【請求項13】上記ニオブ酸リチウム単結晶からなる複屈折板の軸方位に対して、その熱膨張係数に合わせた複数の接着剤を用いてパッケージに接合することを特徴とする請求項9乃至12のいずれかに記載の撮像装置。

【請求項14】上記ニオブ酸リチウム単結晶内の温度差が30度以下になるようにしてパッケージに接合した

ことを特徴とする請求項9乃至13のいずれかに記載の撮像装置。

【請求項15】請求項1乃至8のいずれかに記載の光学フィルタ、又は請求項9乃至14のいずれかに記載の撮像装置を用いたことを特徴とする撮像機器。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明はデジタルカメラや携帯端末などの撮像機器と、これらに用いる光学フィルタ及び撮像装置に関する。

【0002】

【従来の技術】一般的に画像撮像素子として用いられるCCD(Charge Coupled Device)やCMOS(Complementary Metal Oxide Semiconductor)等は周期的に画素が配列されている。これらの素子を用いた場合、撮像素子のサンプリング周波数の1/2以上の高周波成分が含まれると偽信号として取り込まれモアレ等の問題を発生させる。このため図3に示すように、パッケージ11に収納されてカバーガラス14で封止された撮像素子12と対物レンズ8との間に、複屈折板や回折格子等からなる光学フィルタ13がおかれている(特開平1-254912号、特開平3-284714号公報参照)。

【0003】また、撮像装置の小型化により、図4(a), (b)に示すように撮像素子12を収納するパッケージ11のカバーガラスに光学フィルタ13を設置することもある(特開平1-129671号公報、特開平5-257086号、特開2000-40813号公報参照)。

【0004】上記光学フィルタ13として、一般的に回折格子は精密な形状を形成する事が困難であり、また焦点の関係上、実装位置に自由度が持たせられないことから、複屈折板が好まれる。また、この複屈折板の材質としては水晶が一般的に用いられる。

【0005】この光学フィルタ13は、図5(a), (b)に示すように水晶からなる複屈折板16, 18と1/4波長板17を積層し、これらの間に赤外線遮断層19としてガラス板が挟まれていたり、コートを施したりしている。

【0006】通常これらの撮像素子12を用いる場合、撮像素子12が赤外光に対し感度がよいことから取り込まれた画像は一般的に赤味を帯びてしまうため、ある範囲で赤外光を遮断する必要があり、図5(a), (b)に示すように赤外線遮断層19を配置している。

【0007】

【発明が解決しようとする課題】現在、これら撮像素子を用いた装置ではさらに小型・薄板化が望まれている。

【0008】しかし、水晶からなる複屈折板16, 18での光学フィルタ13では複屈折が小さいため薄板化が困難であった。薄板化は複屈折の大きな材料により可能

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となるが、その材料としてルチル (TiO_2) や方解石 ($CaCO_3$) 等を用いると、品質の安定性、供給の安定性、価格、大きさ等の点で問題があった。

【0009】

【課題を解決するための手段】本発明ではニオブ酸リチウム単結晶からなる複屈折板を光学フィルタに用いることで小型・薄板化を図るとともに、このニオブ酸リチウム単結晶からなる複屈折板に可視光域400～550nmでの透過率85%以上で赤外光域725～1000nmでの透過率15%以下の赤外線遮断層を積層したことを特徴とする。

【0010】また本発明は、ニオブ酸リチウム単結晶からなる複屈折板を複数枚積層させた構造とし、少なくとも3枚用いて各複屈折板の光軸投影方向を45度乃至90度にして、光を正方もしくは長方分離して画素ピッチに合わせた光学フィルタとしたことを特徴とする。さらに、この複数枚積層させた複屈折板の少なくとも1枚を水晶に置き換わり、あるいは1/4波長板に置き換えても分離効果は得られる。

【0011】さらに本発明は、上記赤外線遮断層としてP-V値が10%以内であり、光の入射角度20度以内における透過率の半値波長の変動が±15nm以下とする膜を付けることで、更に小型・薄板化を図るようにしたものである。

【0012】また本発明は、上記複屈折板にそれぞれ接する物に対しての反射防止膜を施すことで透過率を向上させ、光学フィルタ全体の可視光域400～550nmでの透過率を85%以上とした物である。

【0013】さらに本発明は、上記光学フィルタを撮像素子の収納用パッケージに備えることで撮像装置の小型・薄板化を図るようにしたものである。

【0014】また本発明は、上記光学フィルタをパッケージに接合するための接合剤として紫外線硬化型などの温度が上がらない物を用いたり、加熱を必要とする接合剤においてはニオブ酸リチウム単結晶に近似した $8 \times 10^{-4} \sim 3 \times 10^{-6}$ /°Cの熱膨張係数を有する物にして割れを防ぐようにしたものである。またニオブ酸リチウム単結晶からなる複屈折板の軸方位に応じて数種の接合剤を同時に用いて接合したり、接合工程でのニオブ酸リチウム単結晶内の温度差を30度以内にすることで割れを防ぐようにしたものである。

【0015】

【発明の実施の形態】本発明の光学フィルタを図1に示す。

【0016】ニオブ酸リチウム単結晶からなる複屈折板1、2、3と赤外線遮断層4を図1のように積層させて光学フィルタ9を構造する。この赤外線遮断層4の接合場所は複屈折板1、2、3の表面、もしくは複数の複屈折板1、2、3の間であっても良い。また、この赤外線遮断層4は固体でも薄膜でも良い。

【0017】詳細を後述するように図2に示すCCD及びCMOS等の撮像素子12は周期的に画素が配列され、それに色フィルターが周期的に付けられているので、上記のように少なくとも3枚の複屈折板1、2、3を用いて、互いの結晶光軸投影方向を45度乃至90度の角度をもって交差させて、入射光を正方または長方の4点に均等な光に分離させることで、その撮像素子12の画素ピッチに対応した光学フィルタ9とする事ができる。

【0018】また、複屈折板1、2、3のうち、中間の複屈折板2を1/4波長板に置き換えた構成でも良い。この1/4波長板は水晶やニオブ酸リチウム単結晶等を結晶方位や厚みを設計して用いる。

【0019】さらに複屈折板1、2、3の少なくとも1枚を水晶に置き換えて、同様の光の分離効果を得ることができる。

【0020】さらに、図1では3枚の複屈折板を用いたが、1枚のニオブ酸リチウム単結晶からなる複屈折板1のみでも光学フィルタ9として用いることができる。赤外線遮断層4は可視光域である波長400～550nmの光を透過して、赤外光域である波長725～1000nmの光をカットする性質を持つ。この可視光域400～550nmでの透過率はそのまま撮像素子で取り込まれた映像の明るさに影響するため高い方が好ましく、また、赤外光域725～1000nmでの透過率は映像の赤味に大きく影響するため低い方が好ましく、中間の550～725nmでは連続的にシャープに透過率を減少させることができ。特に可視光域である波長400～550nmでの透過率は85%以上で、赤外光域である波長725～1000nmでの透過率が15%以下であるものを用い、さらに透過率50%の半値波長が635±15nmになる様にした状態で連続的に波長域につながったものを用いれば、得られた映像は人の感度に近い状態で好ましい。

【0021】また、被写体からの光は光学フィルタ9の垂直方向に対して20度以内で入射されるため、その範囲で分光透過率の変動が大きくなると量産時に個々の透過率特性にあったデジタル信号処理が必要になり、大変手間を取る。そのため入射角度20度以内での透過率の半値波長の変動は小さいことが好ましく、±15nm以下であることが望まれる。

【0022】ただし、赤外線遮断層4が薄膜の場合はニオブ酸リチウム単結晶からなる複屈折板1、2、3の屈折率が大きいため、図6に従来の薄膜として示すように可視光域400～650nmで数カ所に及び透過率がおちるリップルが発生する事になる。これを防止するためには、赤外線遮断層4として数層にわたり酸化チタン (TiO_2) 等の高屈折材と酸化珪素 (SiO_2) 、弗化マグネシウム (MgF) 等の低屈折材からなる薄膜を順番に積層して400～550nmでの透過率を85%以

上にして、そのP-V値を10%以下にすることが好ましい。また、透過率50%の半値波長を $625 \pm 25\text{ nm}$ で赤外光域725~1000nmでの透過率を15%以下にしたシャープカットな赤外線遮断層4を構成することがさらに好ましい。成膜の方法は蒸着法、スパッタ法等で可能である。

【0023】また、複屈折板1、2、3や赤外線遮断層4の各正面にそれぞれの接する物質に対する反射防止膜5、6、7を形成することで、図7に示すように光学フィルタ9全体の可視光域400~550nmでの透過率を85%以上にすることができる。

【0024】光学フィルタ9として構成するニオブ酸リチウム単結晶からなる複屈折板1、2、3および赤外線遮断層4の接合には透光性接着剤を用いたり、機械的な接合でも可能である。

【0025】こうして得た本発明の光学フィルタ9を撮像装置に用いた例を図2に示す。

【0026】CCDまたはCMOS等の撮像素子12がパッケージ11に収納されており、その撮像素子12の受光面側にパッケージ11の開口部があり、そこには透光性があり撮像素子12を保護し封止するためのカバーガラスと兼用して、図1に示す光学フィルタ9を用い *

*で、接合剤10で接合する。

【0027】一般にCCD及びCMOS等の撮像素子12は周期的に画素が配列され、それに色フィルターが周期的に付けられているので、特に複屈折板1、2、3を少なくとも3枚用いて、互いの結晶光軸投影方向を45度乃至90度の角度をもって交差させて、入射光を正方または長方の4点に均等な光に分離させることで、その撮像素子12の画素ピッチに対応した光学フィルタ9を備えることにより、従来、光学フィルタ9が置かれていたスペースが削減する事ができる。

【0028】上記接合剤10としては、ニオブ酸リチウム単結晶と熱膨張が近似した接着剤、ガラス材、樹脂材等を用い、特に熱膨張係数 $8 \times 10^{-6} \sim 3 \times 10^{-6}/^{\circ}\text{C}$ 程度の熱硬化接合剤が好ましい。

【0029】また、本発明で複屈折板1、2、3として用いるニオブ酸リチウム単結晶は、表1のように光軸投影方向とそれに垂直方向では熱膨張が異なるため、それぞれの方向で熱膨張の近似した複数の接合剤10を用いることが好ましい。

【0030】

【表1】

	光軸方向(C軸)	光軸垂直方向(a軸)
熱膨張係数(/°C)	7.5×10^{-6}	15.4×10^{-6}

【0031】あるいは、接合剤10として熱がかからない紫外線硬化型の接着剤を用いることもできる。

【0032】また、接合時にはニオブ酸リチウム単結晶内で部分的に大きな温度差があるとクラックが発生しやすくなるため、単結晶内の温度差が30度以下となるようして製造することが好ましい。

【0033】このように、本発明のニオブ酸リチウム単結晶からなる複屈折板1、2、3を用いて赤外線遮断層膜4を備えた光学フィルタ9を、撮像素子12収納用パッケージ11に設置することで、大幅に光学系の距離の短縮が可能になり、撮像装置の小型、薄板化ができる。

【0034】そのため、このような本発明の光学フィルタや撮像装置をデジタルカメラなどの撮像機器に用いれば、小型、薄板化することができる。

【0035】

【実施例】結晶光軸面から45度傾けたニオブ酸リチウム単結晶からなる4インチサイズの複屈折板を3枚用いて、図1の光学フィルタ9を構成する。1枚目の複屈折板1は基板厚み0.31mmにして、仮にその基板内の光軸投影方向線を0度とした場合、2枚目、3枚目の複屈折板2、3の光軸投影方向線を+45度、-45度にする。その2枚目、3枚目の複屈折板2、3の厚みはそれぞれ0.22mmとした。

【0036】それぞれの複屈折板1、2、3は接する物に応じた反射防止膜5、6、7を両面に施す。1枚目の

複屈折板1の片面には空気に対しての反射防止膜5を施し、他面には反射防止膜7と赤外線遮断層4の膜とを施した。赤外遮断層4の膜は酸化チタンと酸化珪素の薄膜を順番に20層以上積層して、可視光域400~550nmでの透過率が85%以上で赤外光域725~1000nmでの透過率が15%以下で可視光域400~550nmでの透過率のP-V値が10%以下の特性を出した。

【0037】2枚目の複屈折板2は両面に屈折率1.5前後の透光性接着剤に対しての反射防止膜6を施し、3枚目の複屈折板3には片面に前記同様の接着剤に対する反射防止膜6を施し、他面には空気に対する反射防止膜5を施した。

【0038】赤外線遮断層4の膜および反射防止膜5、6、7は蒸着法で被着したが、スパッタ法等でも可能である。これらの複屈折板1、2、3を順番に光軸投影方向を前記角度に正確に保ちながら、前記の接着剤にて接着固定した。

【0039】こうして得られた光学フィルタ9の分光透過率は図6、図7に示すように可視光域400~550nmでの透過率が85%以上でリップルの小さい特性に改善された。

【0040】透光性接着剤の屈折率は特に限定ではなく、その屈折率に応じた反射防止膜を施せばよい。接着剤の硬化方法も紫外線硬化、熱硬化等で限定はないが、信

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頼性や複屈折板の熱特性を考慮すると紫外線硬化型の接着剤が好ましい。

【0041】こうして得られたニオブ酸リチウム単結晶からなる3枚の複屈折板と赤外線遮断層を積層した光学フィルターをダイシング加工により 30×30 程度ヘチップ化する。

【0042】この光学フィルタは可視光域での透過率で90%以上を保ち、正方に約 $12 \mu\text{m}$ のピッチで4点に分離する。

【0043】このチップを図2のようにCCD撮像素子12が収納されたパッケージ11の受光部側のカバーガラスとして接合する。

【0044】接合方法は紫外線硬化型の接着剤を用いて光学フィルター全周を接着する。他に熱硬化接着剤、樹脂、ガラス等を用いた接合も可能だが、加熱する場合は、その熱膨張係数をニオブ酸リチウム単結晶に類似した物を選択する必要がある。また、光学フィルタを積層するときに用いた接着剤の熱特性も考慮する必要がある。

【0045】こうして得られた光学フィルタを一体にした撮像装置を用いた光学系は、従来のフィルタが分離している撮像装置の光学系に比べ設置スペースが約 $1/3$ 以下の厚みになり、水晶の光学フィルタを一体にした撮像装置の光学系の設置スペースの約 $1/2$ の厚みにする事が可能になる。

【0046】

【発明の効果】本発明によれば、ニオブ酸リチウム単結晶からなる複屈折板を用いて、光学フィルタを構成し、それを撮像素子が収納されるパッケージのカバーとして用いることで小型・薄板化された撮像装置が可能になる。また、これを実現するに当たり光学フィルタを破損させない製造方法と、ニオブ酸リチウム単結晶に対し要求される特性を持った赤外線遮断層の膜の製造を可能にする。

* 【図面の簡単な説明】

【図1】本発明の光学フィルタを示す図である。

【図2】本発明の撮像装置を示す断面図である。

【図3】従来の撮像装置を示す断面図である。

【図4】(a) (b) は従来の撮像装置を示す断面図である。

【図5】(a) (b) は従来の光学フィルタを示す図である。

【図6】光学フィルタにおける赤外線遮断層の光透過率を示した図である。

【図7】本発明の光学フィルタにおける光透過率を示した図である。

【符号の説明】

1 : 複屈折板

2 : 複屈折板

3 : 複屈折板

4 : 赤外線遮断層

5 : 反射防止膜

6 : 反射防止膜

7 : 反射防止膜

8 : レンズ

9 : 光学フィルタ

10 : 接合剤

11 : パッケージ

12 : 撮像素子

13 : 光学フィルタ

14 : カバーガラス

15 : 接合剤

16 : 複屈折板

17 : 複屈折板

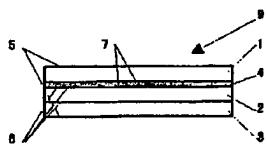
18 : 複屈折板

19 : 赤外線遮断層

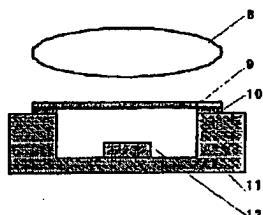
20 : 反射防止膜

*

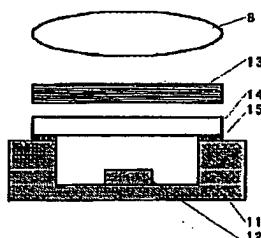
【図1】



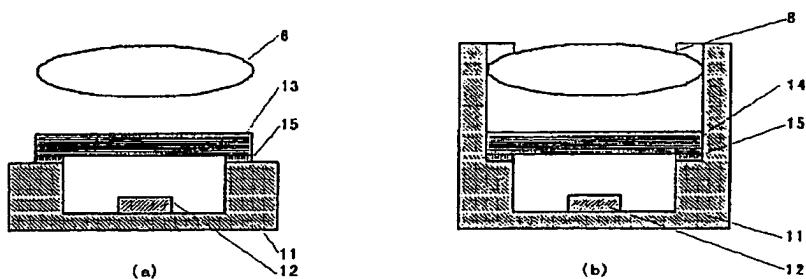
【図2】



【図3】



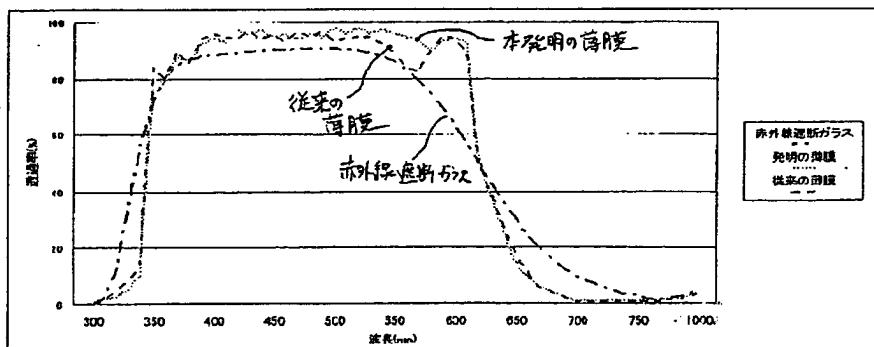
【図4】



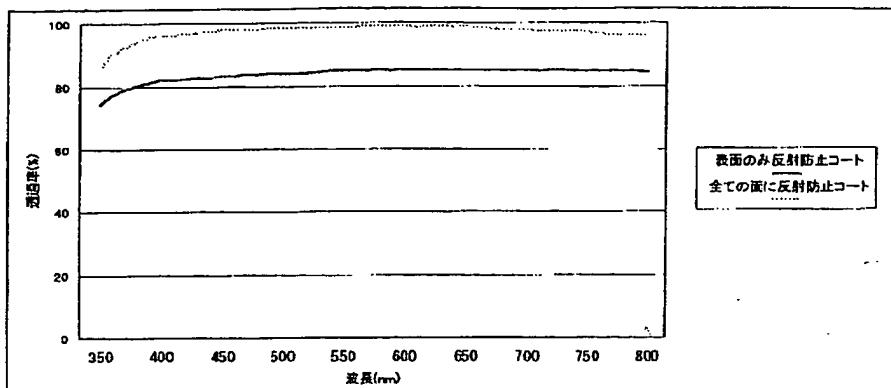
【図5】



【図6】



【図7】



Date: July 24, 2003

Declaration

*I, Megumi Odawara, a translator of Fukuyama Sangyo Honyaku Center, Ltd., of
16-3, 2-chome, Nogami-cho, Fukuyama, Japan, do solemnly and sincerely
declare that I understand well both the Japanese and English languages and
that the attached document in English is a full and faithful translation, of the
copy of Japanese Unexamined Patent Publication No. 2002-286934 laid open
on October 3, 2002.*



Megumi Odawara

Fukuyama Sangyo Honyaku Center, Ltd.

OPTICAL FILTER, PICKUP DEVICE USING THE OPTICAL FILTER, AND
PICKUP APPARATUS USING THE PICKUP DEVICE

Japanese Unexamined Patent No. 2002-286934

Laid-open on: October 3, 2002

Application No. 2001-93760

Filed on: March 28, 2001

Inventor: Satoshi TSUBOKURA

Applicant: Kyocera Corporation

SPECIFICATION

[TITLE OF THE INVENTION] OPTICAL FILTER, PICKUP DEVICE USING
THE OPTICAL FILTER, AND PICKUP APPARATUS USING THE PICKUP
DEVICE

[Abstract]

[Object] To provide a pickup device and a method therefor in
order to make small and thin an optical system including an
optical filter, for the purpose of making small and thin an
image pickup apparatus.

[Solving Means] An infrared ray blocking layer is laminated
on a birefringent plate consisting of niobic lithium
monocrystals to obtain an optical filter, and the optical
filter is used as a cover glass of a package in which a pickup

device is accommodated.

[WHAT IS CLAIMED IS;]

[Claim 1] An optical filter that is composed by laminating an infrared ray blocking layer whose transmission factor is 85% or more with respect to light the wavelength of which is 400 through 550nm, which is in a visible light range, and whose transmission factor is 15% or less with respect to light the wavelength of which is 725 through 1000nm, which is in an infrared ray range, on a birefringent plate consisting of niobic lithium monocrystals.

[Claim 2] An optical filter, having a plurality of said birefringent plates laminated, in which said infrared ray blocking layer is laminated on the extreme outer side thereof or therebetween.

[Claim 3] The optical filter as set forth in Claim 2, wherein at least three birefringent plates are laminated, the optical axis projecting directions of the respective plates are made into 45 degrees through 90 degrees, and transmission light is separated in the form of a square or rectangle.

[Claim 4] The optical filter as set forth in Claim 2 or 3, wherein at least one of a plurality of said laminated birefringent plates is substituted by quartz crystal.

[Claim 5] The optical filter as set forth in any one of Claims

2 through 4, wherein at least one of a plurality of said laminated birefringent plates is substituted by a 1/4 wavelength plate.

[Claim 6] The optical filter as set forth in any one of Claims 1 through 5, wherein, as said infrared ray blocking layer, the P-V (Peak-Valley) value of the transmission factor of light the wavelength of which is from 400 through 550nm which is in a visible light range, is 10% or less.

[Claim 7] The optical filter as set forth in any one of Claims 1 through 6, wherein, in regard to said infrared ray blocking layer, a fluctuation in the mesial magnitude wavelength of the transmission factor is $\pm 15\text{nm}$ or less within 20 degrees in the incident angle of light.

[Claim 8] The optical filter as set forth in any one of Claims 1 through 7, wherein the transmission factor of light the wavelength of which is 400nm through 550nm which is in a visible light range is 85% or more.

[Claim 9] A pickup device including a birefringent plate consisting of niobic lithium monocrystals on the opposite side of a light receiving side of a pickup element accommodated in a package.

[Claim 10] The pickup device as set forth in Claim 9, wherein a plurality of said birefringent plates are laminated.

[Claim 11] A pickup device including an optical filter, as set forth in Claims 1 through 8, on the opposite side of the light receiving side of the pickup element accommodated in a package.

[Claim 12] The pickup device as set forth in Claims 9 through 11, wherein, using an ultraviolet ray hardening agent or an adhesive agent having a thermal expansion coefficient of 8×10^{-5} through $3 \times 10^{-6}/^{\circ}\text{C}$, said birefringent plate or optical filter is bonded to the package.

[Claim 13] The pickup device as set forth in any one of Claims 9 through 12, wherein said birefringent plate or optical filter is bonded to the package, using a plurality of adhesive agents in accordance with the thermal expansion coefficients with respect to the axial direction of the birefringent plate consisting of said niobic lithium monocrystals.

[Claim 14] The pickup device as set forth in any one of Claims 9 through 13, wherein said birefringent plate or optical filter is bonded to the package so that a difference in temperature becomes 30 degrees or less in said niobic lithium monocrystals.

[Claim 15] A pickup apparatus including an optical filter as set forth in any one of Claims 1 through 8 and a pickup device as set forth in any one of Claims 9 through 14.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Field of the Invention] The present invention relates to a pickup apparatus such as a digital camera and portable terminal device, an optical filter used therefor, and a pickup device used therefor.

[0002]

[Prior Arts] Generally, pixels are cyclically arrayed in CCD (Charge-Coupled Device) and CMOS (Complementary Metal-Oxide Semiconductor), etc., which are used as image pickup elements. Where these devices are used, if harmonic components which are larger than one-half the sampling frequency of the pickup device are included, these are taken in as false signals, wherein a problem such as moire occurs. Therefore, as shown in Fig. 3, an optical filter 13 consisting of a birefringent plate and a diffraction grating, etc., is disposed between a pickup element 12 and an object lens 8, which are accommodated in a package 11 and sealed by a cover glass 14 (Refer to Japanese Unexamined Patent Publication Nos. Hei-1-254912 and Hei-3-284714).

[0003] Also, in line with downsizing of a pickup apparatus, as shown in Figs. 4(a) and 4(b), there may be cases where an optical filter 13 is installed on the cover glass of a package 11 that accommodates a pickup element 12 (Refer to Japanese Unexamined Patent Publication Nos. Hei-1-129671, Hei-5-257086

and 2000-40813).

[0004] Generally, since it is difficult to form an accurate shape with respect to a diffraction grating, and the mounting position cannot be freely secured due to the focusing point, a birefringent plate is preferred. In addition, quartz crystal may be generally used as a material of the birefringent plate.

[0005] As shown in Fig. 5(a) and 5(b), the optical filter 13 is such that birefringent plates 16 and 18 composed of quartz crystal and 1/4 wavelength plate 17 are laminated, a glass sheet is placed as an infrared ray blocking layer 19 therebetween or coating is carried out.

[0006] Where the pickup elements 12 are generally used, since the pickup elements 12 are sensitive to the infrared light, a picked-up image may be generally turned red. Therefore, it is necessary to block the infrared light to a certain range. As shown in Figs. 5(a) and 5(b), the infrared ray blocking layer 19 is provided.

[0007]

[Objects to be Solved by the Invention] At present, further downsizing and thinning are preferred in devices using the pickup apparatuses.

[0008] However, since, in the optical filter 13 composed of birefringent plates 16 and 18 consisting of quartz crystal,

the birefringence is slight, thinning thereof is difficult. The thinning is enabled by a material having high birefringence. However, if rutile (TiO_2) and calcite ($CaCO_3$) are used as the material, there are problems with respect to the stability of quality, stability of supply, price, and/or size, etc.

[0009]

[Means for Solving the Problems] The present invention is featured in that downsizing and thinning can be achieved by a birefringent plate consisting of niobic lithium monocrystals for an optical filter, and an infrared ray blocking layer, whose transmission factor is 85% or more at a visible light zone of 400 through 550nm and whose transmission factor is 15% or less at an infrared light zone of 725 through 1000nm, is laminated on the birefringent plate consisting of niobic lithium monocrystals.

[0010] Also, the present invention provides a structure in which a plurality of birefringent plates consisting of niobic lithium monocrystals are laminated, wherein at least three birefringent plates are laminated, the optical axis projecting directions of the respective birefringent plates are made into 45 degrees through 90 degrees, and transmission light is separated in the form of a square or rectangle, thereby obtaining an optical filter matched to an pixel pitch.

Furthermore, even where at least one of the birefringent plates laminated in a plurality is substituted by quartz crystal, or is substituted by a 1/4 wavelength plate, an effect of separation can be brought about.

[0011] In addition, the present invention achieves further downsizing and thinning by attaching a film for which a P-V value is 10% or less as the infrared ray blocking layer, and a fluctuation in the mesial magnitude wavelength of the transmission factor is $\pm 15\text{nm}$ or less within 20 degrees in the incident angle of light.

[0012] The present invention provides an optical filter, in which the transmission factor is increased and the transmission factor is made into 85% or more in a visible light zone of 400 through 550nm in the entirety of the optical filter, by applying an antireflective coating to substances respectively brought into contact with the above-described birefringent plates.

[0013] Also, the invention achieves the downsizing and thinning of a pickup devices by providing the above-described optical filter in a package for accommodating a pickup element.

[0014] In addition, with the invention, a substance that does not raise the temperature, such as an ultraviolet ray hardening type, is used as an adhesive agent to cement the above-described optical filter to the package, and cracking is prevented from

occurring with respect to a substance, whose thermal expansion coefficient is 8×10^{-5} through $3 \times 10^{-6}/^{\circ}\text{C}$ approximate to the niobic lithium monocrystals, in an adhesive agent that requires heating. Furthermore, several types of adhesive agents may be simultaneously used in response to the axial direction of the birefringent plate consisting of niobic lithium monocrystals, or cracking can be prevented from occurring by suppressing a difference in temperature within 30 degrees in the niobic lithium monocrystals in the bonding process.

[0015]

[Embodiments of the invention] An optical filter according to the invention is illustrated in Fig. 1.

[0016] The optical filter 9 is constructed by laminating birefringent plates 1, 2 and 3, which consist of niobic lithium monocrystals, and an infrared ray blocking layer 4 as shown in Fig. 1. The infrared ray blocking layer 4 may be bonded on the surface of the birefringent plates 1, 2 and 3 or may be bonded between a plurality of the birefringent plates 1, 2 and 3. Also, the infrared ray blocking layer 4 may be solid or a thin film.

[0017] As shown in the detail below, since pixels are cyclically arrayed in pickup elements 12 such as a CCD, CMOS, etc., and a color filter is cyclically attached thereto, the optical axis

projecting directions of respective crystals are crossed at an angle of 45 through 90 degrees by using at least three birefringent plates 1, 2 and 3 as described above, and the incident light is divided into uniform lights at four points in the form of a square or rectangle, wherein it is possible to obtain an optical filter 9 corresponding to the pixel pitch of the pickup element 12.

[0018] Furthermore, it may be constructed that the intermediate birefringent plate 2 of the birefringent plates 1, 2 and 3 is substituted by a 1/4 wavelength plate. The 1/4 wavelength plate may be composed by designing the crystallization direction and thickness of quartz crystal and niobic lithium monocrystals, etc.

[0019] In addition, even if at least one of the birefringent plates 1, 2, and 3 is substituted by quartz crystal, a similar separation effect of light can be obtained.

[0020] Furthermore, although three birefringent plates are used in Fig. 1, only a birefringent plate 1 consisting of one niobic lithium monocrystal may be used as the optical filter 9. The infrared ray blocking layer 4 has a feature that transmits light, whose wavelength is 400 through 550nm in the visible light zone, and cuts off light whose wavelength is 725 through 1000nm in the infrared light zone. Since the

transmission factor in the visible light zone of 400 through 550nm influences the brightness of a picture picked up by the pickup element as it is, the higher the better. Also, since the transmission factor in the infrared light zone of 725 through 1000nm greatly influences the redness, the lower the better. It is favorable that the transmission factor is continuously sharply decreased in the intermediate zone from 550 through 725nm. In particular, an optical filter is used, in which the transmission factor is 85% or more at a wavelength of 400 through 550nm in the visible light zone, and the transmission factor is 15% or less at a wavelength of 725 through 1000nm in the infrared light zone, and further an optical filter is used, in which the wavelength zone is continued so that the mesial magnitude wavelength at 50% of the transmission factor becomes $635 \pm 15\text{nm}$, wherein a picture thus obtained approximates the sensitivity of a human.

[0021] Also, since light from a subject is made incident within 20 degrees with respect to the vertical direction of the optical filter 9, it becomes necessary to process digital signals in response to individual characteristics of the transmission factor, when carrying out mass production, in line with an increase in fluctuations of the spectral transmission factor in the range, this becomes very cumbersome. Therefore, it is

favorable that the fluctuation in the mesial magnitude wavelength is slight when the incident angle is within 20 degrees, and it is highly recommended that the fluctuation is $\pm 15\text{nm}$ or less.

[0022] However, since the refractive index of the birefringent plates 1, 2 and 3 consisting of niobic lithium monocrystals is large where the infrared ray blocking layer 4 is a thin film, a ripple is brought about, by which the transmission factor drops at several points in the visible light zone of 400 through 550nm as shown as a prior art example in Fig. 6. In order to prevent this, thin films composed of a high refractive material such as titanium oxide (TiO_2), etc., and low refractive material such as silica oxide (SiO_2) and magnesium fluoride (MgF), etc., are laminated by several layers as the infrared ray blocking layer 4 in order, the transmission factor at 400 through 550nm is made into 85% or more, wherein it is preferable that the P-V value is set to 10% or less. In addition, it is further preferable to construct a sharp-cut infrared ray blocking layer 4, in which the mesial magnitude wavelength of the transmission factor of 50% is $625 \pm 25\text{nm}$ and the transmission factor in the infrared light zone of 725 through 1000nm is made into 15% or less. Films may be formed by an evaporation coating method or a spattering method, etc.

[0023] By forming antireflective coatings 5, 6 and 7 with respect to substances brought into contact with respective main planes of the birefringent plates 1, 2 and 3 and the infrared ray blocking layer 4, it is possible to make the transmission factor into 85% or more in the visible light zone of 400 through 550nm of the entirety of the optical filter 9 as shown in Fig. 7.

[0024] In regard to bonding of the birefringent plates 1, 2 and 3 consisting of niobic lithium monocrystals and the infrared ray blocking layer 4, which constitute the optical filter 9, a permeable adhesive may be used, or a mechanical joint may be available.

[0025] Fig. 2 shows an example in which an optical filter according to the invention, which is thus obtained, is applied to a pickup apparatus.

[0026] A pickup element 12 such as a CCD and CMOS, etc., is accommodated in the package 11, and an opening portion of the package 11 is provided at the light receiving side of the pickup element 12, where an optical filter 9 shown in Fig. 1 is used and bonded thereto by an adhesive agent 10, as it is concurrently used as a cover glass that has transmittance and protects and seals the pickup element 12.

[0027] Generally, since pixels are cyclically arrayed in pickup

elements 12 such as a CCD and CMOS, etc., and color filters are cyclically attached thereto, the optical axial projecting directions of respective crystals are crossed at an angle of 45 through 90 degrees by using at least three of the birefringent plates 1, 2 and 3, and the incident direction are divided into uniform lights at points in the form of a square or rectangle, and an optical filter 9 corresponding to pixel pitches of the pickup elements 12 is provided, wherein it is possible to decrease the space where an optical filter 9 is conventionally placed.

[0028] An adhesive, glass material and resin material, etc., may be used as the above-described adhesive agent 10, the thermal expansion of which is approximate to that of the niobic lithium monocrystals. In particular, a thermosetting adhesive whose thermal expansion is 8×10^{-5} through $3 \times 10^{-6}/^{\circ}\text{C}$ or the like is preferable.

[0029] Also, in the invention, the thermal expansion coefficient of the niobic lithium monocrystals used as the birefringent plates 1, 2 and 3 in the optical axis projecting direction is different from that in the direction perpendicular thereto as in Table 1. Therefore, it is preferable that a plurality of adhesive agents 10, the thermal expansions of which are approximate to each other in the respective

directions, is used.

[0030]

[Table 1]

	Optical axis direction (C axis)	Direction perpendicular to the optical axis (a axis)
Thermal expansion coefficients ($^{\circ}\text{C}$)	7.5×10^{-6}	15.4×10^{-5}

[0031] Or, a UV curing adhesive to which no heat is applied may be used as the adhesive agent 10.

[0032] Also, since a crack is liable to occur if there is a large difference in temperature in part of the niobic lithium monocrystals during joining, it is preferable to produce the monocrystals so that the difference in temperature becomes 30 degrees or less in the monocrystals.

[0033] Thus, where an optical filter 9 provided with an infrared ray blocking layer 4 using the birefringent plates 1, 2 and 3 consisting of niobic lithium monocrystals according to the invention is disposed in the package 11 for accommodating the pickup elements 12, it becomes possible to remarkably shorten the distance of the optical system, wherein it becomes possible to downsize and thin the optical system.

[0035]

[Embodiment] An optical filter 9 shown in Fig. 1 is constructed by using three birefringent plates of 4-inch size, which

consist of niobic lithium monocrystals inclined at 45 degrees from the optical axis plane of the crystals. The substrate thickness of the first birefringent plate 1 is made into 0.31mm. Where it is assumed that the optical axis projecting direction line is 0 degrees in the substrate, the optical axis projecting direction lines of the second and third birefringent plates 2 and 3 are made into +45 degrees and -45 degrees, respectively. The thickness of the second and third birefringent plates 2 and 3 is made into 0.22mm.

[0036] Antireflective coatings 5, 6 and 7 responsive to substances with which the respective birefringent plates 1, 2 and 3 are brought into contact are applied to both sides thereof. An antireflective coating 5 corresponding to air is applied to one side of the first birefringent plate 1, and the antireflective coating 7 and infrared ray blocking layer 4 are applied to the other side thereof. The film of the infrared ray blocking layer 4 is produced by laminating thin films of titanium oxide and silica oxide by 20 or more layers in order, wherein the following characteristics can be obtained, that is, the transmission factor is 85% or more in the visible light zone of 400 through 550nm, the transmission factor is 15% or less in the infrared light zone of 750 through 1000nm, and the P-V value of the transmission factor is 10% or less at the

visible light zone of 400 through 550nm.

[0037] An antireflective coating 6 for a permeable adhesive whose refractive index is 1.5 or so is applied to both sides of the second birefringent plate 2. Furthermore, an antireflective coating 6 for the adhesive agent similar thereto is applied to one side of the third birefringent plate 3, and an antireflective coating 5 for air is applied to the other side thereof.

[0038] Although a film of the infrared ray blocking layer 4 and antireflective coatings 5, 6, and 7 are coated by an evaporation coating method, these films may be coated by a spattering method. The birefringent plates 1, 2 and 3 are adhered and fixed by the above-described adhesive agent while accurately maintaining the optical axis projecting directions at the above-described angle with the birefringent plates 1, 2 and 3 placed in order.

[0039] In the optical filter 9 thus obtained, the spectral transmission factor was improved so that, as shown in Fig. 6 and Fig. 7, the transmission factor is 85% or more in the visible light zone of 400 through 550nm, and characteristics of the ripple is slight.

[0040] There is no special limitation in the refractive index of the permeable adhesive, wherein an antireflective coating

responsive to the refractive index may be coated. Also, there is no limitation with respect to the hardening method of the adhesive agent, wherein ultraviolet curing, thermosetting, etc., may be acceptable. However, the UV curing adhesive is further preferable in view of reliability and thermal characteristics of the birefringent plates.

[0041] An optical filter in which three birefringent plates, thus obtained, consisting of niobic lithium monocrystals, and an infrared ray blocking layer are laminated, is turned into chips, whose size is approximately 30×30 , by dicing.

[0042] The optical filter maintains the transmission factor at 90% or more in the visible light zone, and is divided into 4 points at a pitch of $12\mu\text{m}$ in the form of a square.

[0043] The chip is bonded as the cover glass at the light receiving portion side of the package 11 in which a CCD imager 12 is accommodated, as shown in Fig. 2.

[0044] With respect to the bonding thereof, the entire periphery of the optical filter is bonded and adhered by using an UV curing adhesive. In addition, a thermosetting adhesive, resin, glass, etc., may be used for bonding. However, when heating, it is necessary to select a substance whose thermal expansion coefficient closely approximates that of niobic lithium monocrystals. Also, it is necessary to take thermal

characteristics of the adhesive agent, which are used when laminating the optical filter, into consideration.

[0045] In an optical system in which a pickup device having a thus obtained optical filter integrated is used, the installation space is decreased to a thickness which is approximately one-third, in comparison with the optical system of a pickup device in which separation is carried out by a prior art filter, wherein it is possible to decrease the thickness to approximately one-second the installation space of the optical system of a pickup device in which a quartz crystal optical filter is integrated.

[0046]

[Effects] According to the invention, an optical filter is constructed by using birefringent plates consisting of niobic lithium monocrystals, and is used as a cover of a package in which a pickup element is accommodated, wherein it becomes possible to downsize and thin a pickup device. Furthermore, when achieving the same, a method for producing the optical filter without damaging the optical filter can be brought about, and it becomes possible to produce a film of an infrared ray blocking layer having characteristics that are required for niobic lithium monocrystals.

[Brief Description of the Drawings]

[Fig. 1] is a view showing an optical filter according to the invention;

[Fig. 2] is a sectional view showing a pickup apparatus according to the invention;

[Fig. 3] is a sectional view showing a prior art pickup apparatus;

[Figs. 4] (a) and (b) are sectional views showing prior art pickup apparatuses;

[Figs. 5] (a) and (b) are views showing prior art pickup apparatuses;

[Fig. 6] is a view showing the optical transmission factor of the infrared ray blocking layer of an optical filter; and

[Fig. 7] is a view showing the optical transmission factor in an optical filter according to the invention.

[Description of Reference Numbers]

- 1: Birefringent plate
- 2: Birefringent plate
- 3: Birefringent plate
- 4: Infrared ray blocking layer
- 5: Antireflective coating
- 6: Antireflective coating
- 7: Antireflective coating
- 8: Lens

9: Optical filter
10: Adhesive agent
11: Package
12: Pickup device
13: Optical filter
14: Cover glass
15: Adhesive agent
16: Birefringent plate
17: Birefringent plate
18: Birefringent plate
19: Infrared ray blocking layer
20: Reflection preventing plate



Fig.1

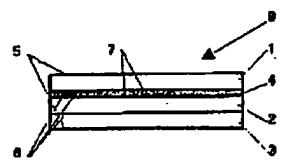


Fig.2

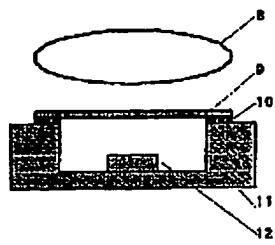


Fig.3

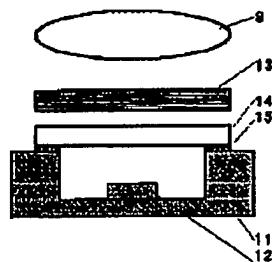


Fig.7

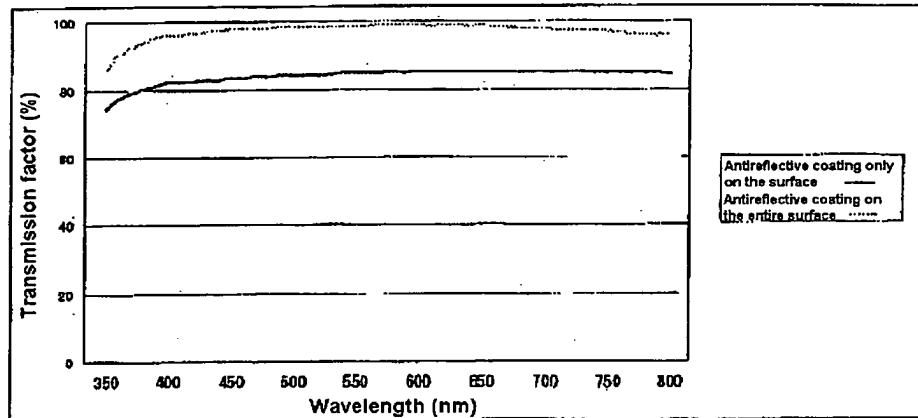




Fig.4

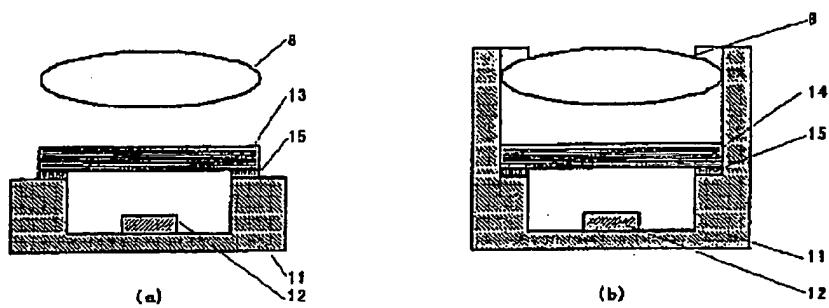


Fig.5



Fig.6

